Annual Highlights

It has been exciting and eventful first year for the Cosmic Dawn Center. Shortly before the center's official start, NASA announced to a surprised community that the launch of the James Webb Space Telescope (JWST) was to be postponed until March 2021. This has slightly modified our research plan, since the involvement of DAWN staff in Guaranteed Time Observations (GTO) planned on JWST instruments is at the heart of our research. Taking advantage of this unexpected delay we have initiated a number of new activities that will maximize our scientific return from JWST once it launches. We are leading several new ground-breaking surveys that will increase by orders of magnitude the number of cosmic dawn galaxies to point the JWST at once it flies. Also, we have built a strong theory group to simulate early galaxy formation, which will greatly aid us in the design and interpretation of JWST observations. DAWN astronomers in Denmark and abroad published a total of 133 peer reviewed papers in 2018, on diverse aspects of the evolution of galaxies over the last 13 billion years of cosmic time, both from an observational and theoretical point of view. Here we highlight two studies, one theoretical [100] and one observational [27].

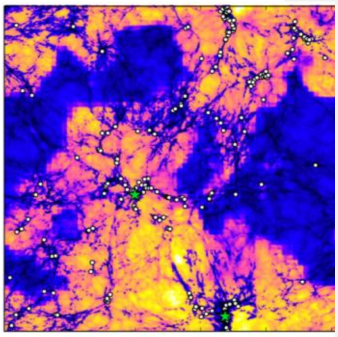

Figure 1 A simulation showing the line-of-sight density of neutral hydrogen at time when the Universe was only 5% of its current age (13.7 billion years). Bright colours indicate regions where the hydrogen has been ionised by the ultraviolet light. These regions are lined by dense filaments of neutral gas (dark colors) along which the galaxies are seen to form (indicated by circles).

Theory: State-of-the-art models for the Universe when it was only a billion years old consistently underestimate the amount of ultraviolet light that circulated between infant galaxies. By dispersing the light from bright quasars, astronomers can detect faint shadows indicating atoms of hydrogen and heavier elements that happen to lie between the Earth and the quasar. Ultraviolet light is energetic enough to strip electrons from those atoms and change their shadows. Through detailed comparisons between observations and models, DAWN scientist **Kristian Finlator** from New Mexico State University found that some of the shadows were not dark enough and some were too dark. Both problems indicate that the young universe was brighter than scientists expect [100]. Where did the missing light come from? Was it from very faint galaxies, quasars, or from some other source? This mystery is spurring further investigations and improvements to models.

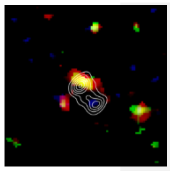

Figure 2: An extremely star forming galaxy observed 1.3 Billion years after the big bang. The color image show shows starlight. The white contours show emission from dust heated by young stars. Thousands of new stars are being born every year under a thick layer of dust that blocks the starlight. The extreme star formation is likely driven by collisions with the small surrounding galaxies.

Observation: Forming stars at a leisurely rate it took our Galaxy 10 billion years to assemble its current stellar mass. DAWN has discovered the most distant known examples of a mysterious type of red compact galaxies, which appears to have formed as many stars as our Galaxy already 12 billion years ago (Schreiber), and with the stars packed 100× closer together [44]. The galaxies appear to have formed 1.3 billion years after the big bang. DAWN PhD student **Carlos Gomez-Guijarro** studied in detail the dust and stars of starburst galaxies at this early epoch and found them to be the likely progenitors of the red compact galaxies seen at later times [27]. These progenitor galaxies form stars 1000× faster than our Galaxy today, but within in a very small volume. The stars are formed under a blanket of dust so thick that all visible light is blocked, only thermal radiation from dust heated by young stars reveals the star formation. The high star formation activity is likely being induced by gas inflows and a constant bombardment of smaller galaxies.